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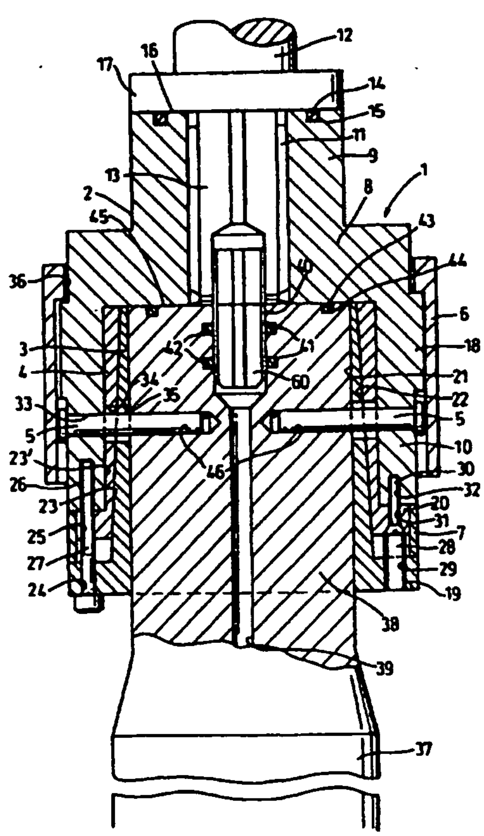
(54) Title: ROTARY DEGASSING APPARATUS WITH ROTOR GRIP COUPLING BETWEEN IMPELLER ROTOR AND DRIVE SHAFT

(57) Abstract

A rotor coupling (1) for connecting a graphite rotor (37) to a drive shaft (12) of a rotary degassing machine comprises a cap (2) which fits over an end of the rotor and contains gripping means (3, 4) to retain the rotor in the cap. The arrangement avoids screw-threaded interconnection between the rotor and drive shaft which necessitates the forming of a screw-thread on the rotor, adds to the cost of rotor manufacture, and quickly wears with use. No, or minimal, special forming of the rotor is needed for engagement by the gripping means. A used rotor which has a worn or broken screw-thread may be held by the gripping means for the rotor to have further useful service. The gripping means preferably comprises two collet-form sleeves (3, 4) which fit one within the other inside the cap and have complementary tapered surfaces (22, 23) which co-operate upon relative axial movement of the sleeves, by means of screws or bolts (27), to cause the inner sleeve (3) to be compressed about the rotor to clamp it to the cap.



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ROTARY DEGASSING APPARATUS WITH ROTOR GRIP COUPLING BETWEEN IMPELLER ROTOR AND DRIVE SHAFT

This invention relates to rotary degassing of metals, more particularly, though not exclusively, aluminium and aluminium alloys.

It is common practice for the degassing of metals, and in particular of aluminium and aluminium alloys, to use a rotary degassing machine having a graphite rotor which is dipped into the melt and rotated to stir a degassing agent well into the molten metal. The degassing agent is usually an inert gas, such as nitrogen or argon, which is supplied through the rotor and bubbled through the melt, the rotation of the rotor breaking up the bubbles and dispersing them through the melt. Alternatively a decomposable solid form of degassing agent may be used which is carried by the rotor and is stirred into the metal by the rotor as it decomposes. The rotor is suspended from and rotated by a powered drive shaft of the machine.

Hitherto a screw-threaded interconnection has been provided between the rotor and drive shaft. A screw thread has been formed on the rotor for that purpose. This adds to the cost of manufacturing the rotor. Also the screw thread of the rotor quickly wears with use, requiring replacement of the rotor at frequent intervals in a continuous foundry process. Furthermore, unless the screw thread is accurately formed the rotor will vibrate as it is rotated. Under the vibration the rotor will whirl around, increasingly further from, the rotational axis of the drive shaft. This stresses the rotor at its connection with the drive shaft and that can result in the rotor's fracturing at the connection.

The present invention addresses these problems.

According to a first aspect of the invention a rotor coupling is provided comprising a cap which is adapted to fit over an end of a graphite rotor and to be connected to a drive shaft of a rotary degassing machine to be rotated thereby, and which contains gripping means for retaining the rotor in the cap co-axially with the drive shaft.

The rotor coupling avoids the need for the rotor to be formed with a screw thread for interconnection with the drive shaft of a rotary degassing machine. The coupling may connect to the rotor without special, or with minimal, forming of the rotor for the connection to be made. A rotor of larger cross-section than has been usual may be connected by the coupling to the drive shaft, to provide a substantially longer useful operating life.

The cap of the coupling may be adapted to be screw-threadedly connected to a drive shaft in similar manner to the conventional connection of a rotor to a drive shaft. The coupling may thus be connected to the usual form of drive shaft provided in rotary degassing machines. The coupling may be adapted to be connected to other forms of drive shaft and by other forms of connections, as appropriate.

The cap may be made in one piece or it may be of a composite form. In the latter case it may comprise, for example, a body part which contains the gripping means and a head part which is attached to the body part and which is adapted to be connected to the drive shaft of a rotary degassing machine. The head part may be adapted to fit different drive shafts or it may be replaceable by one or more other head parts to suit different drive shafts. The head part may therefore serve as a means of adapting the cap for connection to drive shafts of various kinds and sizes.

Preferably the gripping means clamps about the end of the rotor to grip the end all around its periphery. The gripping means may comprise a sleeve which fits around the end of the rotor and has a tapered external surface which co-operates with a complementary surface of the cap, or of a member or members retained to the cap, whereby the sleeve is urged into gripping engagement with the end of the rotor by relative axial movement between the sleeve and the cap. In a preferred embodiment the sleeve is longitudinally slotted and fits as a collet co-axially inside a further, outer, sleeve, which may also be longitudinally slotted, retained to the cap which has an internal tapering surface complementary to and engaged by the tapered external surface of the inner sleeve. The two sleeves are connected to the cap by screw means which, when tightened, urges the sleeves together to clamp the inner sleeve onto the rotor. The screw means may comprise screws or bolts which extend parallel to the common axis of the sleeves. Means may be provided to restrict the extent by which the two sleeves can be urged together. For example, a setting ring may be provided between a flange of the inner sleeve and an opposed abutment face of the cap which restricts axial movement between the sleeve in the clamping direction of the inner sleeve.

Retention means may be made for holding the rotor to the cap when the gripping means is not applied for retaining the rotor in the cap, for example for initial location of the rotor in the cap or retention of the rotor to the cap while the gripping means is released prior to removal of the rotor from the cap. A pin or pins, or the like, may be provided for the purpose insertable laterally of the rotor into a location or locations, such as a hole or holes, recess or groove, in the rotor through a locating aperture or apertures in the cap. Suitable restraint means is preferably included on the cap for preventing unintentional release of the pin or pins

from the rotor. For example, a collar may be mounted on the cap which is movable relative to the cap between operative and inoperative positions. In the operative position the collar overlaps an outer end of the or each pin to prevent withdrawal of the pin or pins from the location or locations in the rotor, and in the inoperative position the collar is moved clear of the pin or pins so as to allow its or their withdrawal from the location or locations for release of the rotor from the cap. As an alternative to the pin or pins, a keeper device may be provided which clamps to the cap and is, or has a part or parts applied to it, adapted to engage with an annular groove in the rotor to retain the rotor in the cap. The keeper device may be in two or more component parts which fit together around the rotor to be clamped to the cap.

The rotor coupling may be used in combination with a rotor as supplied in production form and/or with a rotor which has been attached directly to a drive shaft of a rotary degassing machine, in the conventional way. For example, a used rotor which has had a worn or broken screw-threaded connection to a drive shaft may provide further useful service by being fitted with a rotor coupling in accordance with the present invention and then connected to a drive shaft by the coupling.

According to a second aspect of the present invention there is provided an assembly comprising a graphite rotor and a rotor coupling in accordance with the foregoing first aspect of the invention to which the rotor is removably connected.

The rotor may be of generally cylindrical rod form, conveniently made from extruded stock. It may alternatively be made of square or other non-circular cross-section to assist in the stirring action in a melt. One end of the rotor to which the rotor coupling is fitted may be reduced

in cross-section. The opposite end of the rotor may be enlarged, or have an enlarged end part connected to it to enhance the stirring action of the rotor in use. The enlarged end or end part may be castellated, ribbed or otherwise suitably formed to induce turbulence in the stirring of the melt. It may be reinforced to increase its resistance to wear from the stirring action.

The coupling and rotor may be adapted for a degassing gas, such as nitrogen or argon, to be introduced into a melt. For example, communicating gas passages may be provided in the cap and rotor which, when the coupling is attached to a drive shaft of a rotary degassing machine, connect to a gas supply delivered to the drive shaft. Alternatively, or in addition, the rotor may be adapted to have a degassing agent of a decomposable solid form attached to it. Flux may be added to a melt in combination with a gaseous or solid form of degassing agent.

According to a third aspect of the present invention a rotary degassing machine is provided having a powered drive shaft and an assembly in accordance with the foregoing second aspect of the invention detachably connected to the drive shaft by the rotor coupling.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings, in which:

Figure 1 is enlarged axial sectional view through a first embodiment of a rotor coupling in accordance with the foregoing first aspect of the invention to which a graphite rotor is attached;

Figure 2 is an axial section through an enlarged end part of the rotor;

Figure 3 is a side view of a rotary degassing machine fitted with the rotor coupling and rotor;

Figure 4 is a simplified axial sectional view through a second embodiment of a rotor coupling in accordance with the first aspect of the invention, and

Figures 5 and 6 are an axial cross-section and an underneath plan view of another form of enlarged end part of a rotor.

Referring to Figure 1 of the drawings, a rotor coupling 1 is shown which comprises a cap 2, a pair of co-operating inner and outer sleeves 3 and 4 respectively, which constitute gripping means in the cap, locating pins 5, a sliding collar 6 and a setting ring 7.

The cap 2 comprises a circular crown 8, having a co-axial tubular part 9, and a co-axial cylindrical skirt 10. The cap 2 is made in one piece of machine-formed suitable metal. An internal screw thread 11 is formed in the bore of the tubular part 9 to be complementary to an external screw-threaded lower end 13 of a vertically disposed, conventional, powered drive shaft 12 of a rotary degassing machine. The screw thread 11 is of acme form. A sealing O-ring 14 is located in an angular groove 15 in an upper end face 16 of the tubular part 9 for gas tight sealing engagement with an annular flange 17 of the spindle 12 above the screw-threaded lower end 13. An annular rib 18 around the exterior of the skirt 10 locates the sliding collar 6 on the cap around the skirt. The cap may be made, for example, of steel or aluminium.

The inner and outer sleeves 3, 4 fit co-axially into the skirt 10 of the cap, the inner sleeve 3 being telescoped inside the outer sleeve 4 and the two sleeves each having a longitudinal slot, not shown, along the side so as to be of a collet form. The sleeves may be made of steel. Each sleeve has an annular external flange, 19, 20 respectively, at its lower end. The inner sleeve 3 has a cylindrical bore 21 of constant diameter and an external surface 22 which tapers upwardly from the flange 19 of that sleeve. The outer sleeve 4 has an upwardly tapering bore 23 complementary to the tapered external surface 22 of the inner sleeve 3, and extending from the flange 20 a cylindrical external surface 23' which is a sliding push fit into the skirt 10. Formed in the flanges 19, 20 of the inner and outer sleeves, at angularly spaced positions, are aligned plain-bore through holes 24, 25 whose axes extend parallel to the central axis of the sleeves. At corresponding positions, internally screw-threaded, blind bore, holes 26 are formed in the bottom edge face of the skirt. Locking screws 27 extend through the plain bore holes 24, 25 and tighten into the screw-threaded holes 26 to urge the inner sleeve axially into the outer sleeve. The flange 20 of the outer sleeve seats on the bottom edge face of the skirt 10 and is of a smaller external diameter than the flange 19 of the inner sleeve. Setting ring 7, which is tubular, is fitted between the flange 19 of the inner sleeve and the bottom edge face of the skirt, the flange 20 of the outer sleeve being a free fit inside the setting ring. The setting ring 7 spaces the flanges of the two sleeves apart. It limits the extent by which the inner sleeve can be urged into the outer sleeve by the locking screws 27.

Release screws 28 which have screw-threaded engagement in holes 29 in the flange 19 of the inner sleeve 3 extend at reduced inner portions 30 through plain bore holes 31 in the flange 20 of the outer

sleeve and into plain bore blind holes 32 in the bottom edge face of the skirt. By turning the release screws the inner sleeve 3 can be urged axially outwardly of the outer sleeve.

Locating pins 5 are headed and extend radially of the skirt 10 slidably through plain holes 33 in the skirt below the rib 18, and, with clearance, through aligned plain holes 34, 35 in the outer and inner sleeves. When fully pushed into the holes their heads abut against the exterior of the skirt and are contained substantially within the outward projection of the rib 18 from the general external surface of the skirt.

The sliding collar 6 normally occupies an operative position, as shown in Figure 1, to which it is urged by gravity and in which it extends down past the heads of the fully pushed in locating pins to prevent withdrawal of the pins. An internal bead 36 at the upper end of the collar 6 bears on the upper edge of the rib 18 to define the limit of downward sliding of the collar on the skirt. The collar can simply be lifted above the level of the locating pins when it is required to withdraw them.

The coupling is designed to be used with a graphite rotor 37 which has a plain cylindrical upper end 38. The main body of the rotor 37 may be of cylindrical rod form, or it may be of a non-circular, for example square, cross-section. It may be formed, as is usual, from a length of extruded graphite stock. Bore 21 of the inner sleeve 3 is of a diameter to receive the upper end 38 of the rotor 37 as a close sliding fit. A gas feed passage 39 extends axially through the rotor and has an enlarged inlet 40 adjacent to the top of the upper end 38 of the rotor. Sealing O-rings 41 are located in annular grooves 42 in the inlet 40. Gas supplied axially through the drive shaft 12 to which the coupling is connected for use

enters the gas feed passage 39 of the rotor through a nozzle 60 which locates, and is sealed by the O-rings 41, in the inlet 40. A sealing O-ring 43 is also located in an annular groove 44 formed concentrically in the end face 45 of the upper end 38. Blind radial holes 46 are formed in the upper end, positioned to receive the locating pins 5.

At its bottom end the rotor 37 is fitted with an enlarged end part 47, also of graphite, to promote the stirring action of the rotor. The end part 47 screws onto a reduced diameter, externally screw-threaded, end section 48 of the rotor. It may take various forms. In the form as illustrated in Figure 2, the end part 47 has radial castellations 49 formed on its underside.

To apply the coupling to the rotor 37, the locking screws 27 are first slackened off so that the inner sleeve 3 is a loose fit in the outer sleeve. The locating pins 5 are withdrawn. The upper end 38 of the rotor is then inserted into the bore 21 of the inner sleeve, the upper end being of a length to protrude through the sleeve for its end face 45 to abut against the underside of the crown 8 and be sealed thereto by O-ring 43. Next the locating pins are inserted in the holes 33 of the skirt and pushed through the aligned holes 34, 35 of the outer and inner sleeves to engage in the radial holes 46 in the upper end of the rotor. The rotor is thus loosely retained to the coupling by the locating pins which are then prevented from withdrawal by dropping the sliding collar 6 into its operative position. In order to secure the rotor firmly in the coupling, the locking screws 27 are tightened so as to urge the inner sleeve tightly into the outer sleeve, which action, by the engagement of the tapering external surface 22 of the inner sleeve in the tapering bore 23 of the outer sleeve, causes the inner sleeve to compress onto the outer end of the rotor and

grip it firmly, and centrally, in the coupling. The setting ring 7 prevents over compression of the outer end.

When the coupling has been secured, the rotor is connected to the drive shaft 12 of a rotary degassing machine by securing the tubular part 9 of the cap 2 onto the screw-threaded lower end 13 of the drive shaft. The tubular part 9 is screwed until its upper end face 16 abuts against the annular flange 17 of the drive shaft and the O-ring 14 seals on the flange. The nozzle 60 at the drive shaft engages in the inlet 40 of the gas feed passage 39 in the rotor and is sealed therein by the O-rings 41.

Connection of the rotor and a drive shaft could also be achieved by cutting the tubular part 9 of the cap 2 to a required size, and forming an acme thread on the outer surface thereof. The size and thread of the part 9 are such that the rotor may be located within a portion of the drive shaft, and the rotor and drive shaft connected by means of the thread on the part 9 and a corresponding thread on the drive shaft.

The rotary degassing machine may be of a known form. It may, for example, be a mobile unit as shown in Figure 3 mounted on a trolley 50. In such a machine the drive shaft 12, carried by an arm 51, is powered by a battery driven motor 52 connected to the drive shaft through a belt drive 53. Gas is supplied to the drive shaft from a gas cylinder 54 supported on the trolley 50.

A mains driven rotary degassing machine may be used, as may an overhead, possibly travelling, machine.

The rotor may be readily replaced when it becomes worn with use. The release screws 28 enable the inner sleeve 3 to be eased axially out of

the outer sleeve 4 to relieve the clamping action of the inner sleeve on the upper end of the worn rotor.

It will be appreciated that a rotor originally designed to be screwed directly onto the drive shaft of a degassing machine may be fitted to the coupling if the screw-threaded end of such a rotor is removed, or has been broken away.

The coupling may be made in various sizes to suit a range of rotor sizes. Inner sleeves of different bore sizes may be provided for adapting the coupling for fitting to rotors of various cross-sectional sizes. Different setting rings may also be provided for varying the extent by which the inner sleeve can be urged onto the outer sleeve to suit different rotors.

A number of modifications may be made to the above embodiment. For example, the annular rib 18 on the cap 2 may be omitted, and the heads of the pins 5 recessed into the skirt 10 of the cap. The sliding collar 6 may be provided with an annular lip which extends radially inwards from the upper end of the collar. The collar is then held in an operative position adjacent the outer surface of the skirt 10 and covering the heads of the pins, by abutment of the lip on the shoulder formed between the tubular part 9 and the skirt 10 of the cap 2.

Additional or alternative means for holding the rotor to the coupling may be provided. This may comprise a ring located, for example, in the inner sleeve 3 preferably near the lower end thereof. The ring may be provided in a number of segments, for example 3 or 4. Pins are located at various points around the ring, and in a normal operating position are forced radially inwards, for example by a spring, so that they

protrude through the inner surface of the inner sleeve into the bore 21 thereof. When a rotor having a chamfered leading edge is inserted into the bore, the pins are forced radially outwards so that the rotor may be fully inserted into the bore. When this is achieved, the pins of the ring are aligned with an annular groove provided on the rotor, and the pins are forced radially inwards to locate in the groove. The rotor is thus held to the coupling. Means may be provided to retract the pins so that the rotor may be removed.

This holding means may be used separately from or in addition to the pins 5 described above. Should the locking screws 27 be over-tightened, crushing the upper end of the rotor and impairing the action of the pins 5 and/or the gripping means, this holding means will ensure that the rotor will remain attached to the coupling. The safety of the coupling is therefore enhanced.

The second embodiment illustrated by Figure 4 of the accompanying drawings will now be described. Parts which are similar to those of the first-described embodiment are identified by corresponding reference numerals.

In the second embodiment the rotor coupling 1 again comprises a cap 2, a pair of co-operating inner and outer sleeves 3 and 4 respectively, forming gripping means in the cap, and a setting ring.

The cap 1, instead of being in one piece as in the first embodiment, is made in two parts: a body part 60 and a head part 61. As before, the two parts 60, 61 of the cap may be made, for example, of steel or aluminium. The body part 60 is tubular and substantially similar to the cylindrical skirt 10 of the cap in the first embodiment except that it does

not have the annular rib 18 or the plain holes 33. It is formed with external annular cooling fins 62, has a number of equi-angularly spaced, plain-bore holes 63 extending though it parallel to its central longitudinal axis, and equi-angularly spaced, internally screw-threaded, blind holes 64 extending into it, also parallel to the central longitudinal axis, from a flat upper face 65 of the body part 60. The plain-bore holes 63 are countersunk, 66, at the upper face 65. The head part 61 of the cap has a circular crown 8 and co-axial tubular part 9, generally similar to those of the cap in the first embodiment, the crown 8 fitting over the upper face 65 of the body part 60 to close off the top the body part and the tubular part 9 having an internal screw thread 11 for engagement with the externally screw-threaded lower end 13 of a powered drive shaft 12 of a rotary degassing machine. The tubular part may be otherwise suitably adapted for connection to a drive shaft. There are plain bore holes 67 in the crown 8 at corresponding angular positions to the blind holes 64 of the body part 60. Threaded studs 68 screwed into the blind holes 64 project thorough the plain bore holes 67 and are fitted with retaining nuts 69 to secure the head part 61 firmly on the body part 60. Instead of the plain-bore holes there may be key-hole slots in the crown 8 with which the studs 68 engage for quick fitting and removal of the head part 6 to and from the body part without detaching the retaining nuts 69 from the studs.

Inner and outer sleeves 3, 4 in this second embodiment are essentially the same as those in the first embodiment, being slotted along their sides as collets and having flanges 19, 20 containing plain bore through holes 24, 25, and will not be further described. The plain-bore through holes 25 in the flange 20 of the outer sleeve 4, however, may be replaced by recesses in the flange opening to the edge of the flange. One or more grub-screws 70 are provided for urging the inner and outer sleeves axially apart at their flanges 19, 20 when the sleeves are required

to be separated. A screw or screws 84 may be applied at the flange 20 of the outer sleeve 4 to attach that sleeve to the bottom of the body part 60, and a screw or screws 85 may be applied at the flange 19 of the inner sleeve to attach the inner sleeve to the flange 20 of the outer sleeve.

The manner in which the inner and outer sleeves 3, 4 are retained to the cap and clamp onto a graphite rotor 37 will be described below.

Used in combination with the cap is a keeper ring 71 which is in two equal halves designed to fit around the rotor. The made-up keeper ring 71, which may be made, for example, of steel or aluminium, forms an annulus, of larger external diameter than the flanges 19, 20 of the inner and outer sleeves 3, 4, having an inner circular edge 72 and has internally screw-threaded blind holes 73 opening through an upper face 74 corresponding in number and positions to, so as to register with, the plain-bore holes 63 in the body part 60 of the cap 2. The blind holes 73 extend into bosses 75 formed on the underside of the keeper ring. In this embodiment the rotor 37 to be clamped is formed with a peripheral groove 76 around its upper end and the two halves of the keeper ring 71 fit around the upper end so that the inner circular edge 72 engages in the groove. The keeper ring is retained to the inner and outer sleeves which in turn are retained with the keeper ring to the cap by means of bolts 77 which are passed down through the plain-bore holes 63 of the body part 60 of the cap, through the plain bore through holes 24, 25 of the flanges 19, 20 of the inner and outer sleeves and tightened into the threaded blind holes 73 of the keeper ring. For the insertion and securing of the bolts 77 the body and head parts 60, 61 of the cap are separated. The bolts 77 have socket heads 78 which are received into the countersunk ends 66 of the plain-bore holes 63 so as to lie below the upper face 65 of the body part when the bolts have been secured.

For applying the coupling to the rotor 37, the head part 61 of the cap is removed from the body part 60, the bolts 77 are disconnected from the keeper ring and the inner sleeve 3 is loosely fitted in the outer sleeve. The rotor 37, which has an axial gas feed passage 39 extending through it and a shallow central recess 79 in its upper end face fitted with a sealing washer 80 of high temperature, closed-pore, foam, is inserted into the bore 21 of the upper sleeve until its upper end face is spaced just below the level of the upper face 65 of the body part 60. In that position of the rotor its peripheral groove 76 is disposed just below the level of the underside of the flange 19 of the inner sleeve 3. The two halves of the keeper ring 71 are then fitted around the rotor with its inner circular edge 72 engaging in the groove 76 and the threaded blind holes 73 in register with the plain bore holes 24, 25 of the flanges 19, 20. Next the bolts 77, engaged in the plain-bore holes 63 of the body part 60 and the plain bore holes 24, 25 of the flanges 19, 20, are tightened into the blind holes 73 of the keeper ring. Tightening of the bolts 77 causes the rotor to be urged upwards in the inner sleeve by the interengagement of the keeper ring and groove 76, and also urges the inner sleeve tightly into the outer sleeve. In consequence the inner sleeve is compressed by the interaction of the tapering external surface 22 of the inner sleeve in the tapering bore 23 of the outer sleeve into compressive engagement with the rotor so as to grip the rotor firmly, and centrally, in the cap. As in the first embodiment, over compression of the rotor is prevented by a setting ring 7 located between the bottom of the body part 60 of the cap and the flange 20 of the outer sleeve 4. After the bolts have been tightened the head part 61 of the cap is secured on the body part 60 by means of the studs 68 and retaining nuts 69. As the head part 61 is urged onto the upper face 65 of the body part 60, the foam sealing washer 80 in the recess 79 in the upper end of the rotor becomes compressed to seal the

head and body parts together around the gas feed passage 39 of the rotor. The head part 61 covers over the heads of the bolts.

The rotor is connected to the drive shaft 12 of a rotary degassing machine by securing the tubular part 9 of the head part of the cap 2 onto the screw-threaded lower end 13 of the drive shaft, a before.

The head part 61 of the cap may be interchangeable with other head parts for fitting to the body part to suit the connection of the coupling to drive shafts of different forms and sizes.

The rotor 37 may have or be fitted with an enlarged end part 47, also of graphite, to promote the stirring action of the rotor. The enlarged end part may take the form of that shown in Figure 2 or other forms. An example of another form is shown in Figures 4 and 5 of the drawings. In that example the end part 47 is of square shape in plan with oblon downward projections 81 on its underside. There is one projection adjacent each side of the end part. Each projection 81 extends approximately halfway along the respective side edge from one end of the edge, leaving a gap 82 at the side edge between the end of the projection and the adjacent end of the projection at the next side edge of the end part. Each gap 82 is towards what is the leading edge of the side of the square shape of the end part when the rotor is rotated in use.

Gas supplied down the axial passage 39 of the rotor passes through an axial hole 83 in the end part into the space contained by the projections 81 and is then dispersed though the gaps 82 as the rotor turns. The projections turning through the paths of the gas as the gas passes out of the gaps assists in breaking up the bubbles in the gas flow for better dispersion of the gas through the melt in which the rotor is used.

The stirring action of the rotor in the melt causes wear of the enlarged end part. In order to reduce the rate of wear, plates of hard-wearing material, for example titanium, may be applied over the projections 81. Another possibility is to have the projections, or at least leading portions of them made of a more hard-wearing graphite than the rest of the end part. Yet a further way of reducing the rate of wear is to have the end part of a material which is more hard-wearing than graphite, for example a ceramic material, or a composite of graphite and another hard wearing material or materials.

Claims

1. A rotor coupling characterised in that it comprises a cap (2) which is adapted to fit over an end of a graphite rotor and to be connected to a drive shaft of a rotary degassing machine to be rotated thereby, and which contains gripping means (3, 4) for retaining the rotor in the cap (2) co-axially.

2. A rotor coupling according to Claim 1 characterised in that the cap (2) is adapted to be screw-threadedly connected to a drive shaft.

3. A rotor coupling according to Claim 1 or Claim 2 characterised in that the gripping means (3, 4) is adapted to clamp about the end of the rotor to grip the end all around its periphery.

4. A rotor coupling according to Claim 3 characterised in that the gripping means (3, 4) comprises a sleeve (3) which fits around the end of the rotor and has a tapered surface (22) which co-operates with a complementary surface (23) of the cap, or of a member (4) or members retained to the cap, whereby the sleeve (3) is urged into gripping engagement with the end of the rotor by relative axial movement between the sleeve (3) and the cap (2).

5. A rotor coupling according to Claim 4 characterised in that the sleeve (3) is longitudinally slotted and fits as a collet co-axially inside a further, outer, sleeve (4) retained to the cap (2) which has an internal tapering surface (23) complementary to and engaged by the tapered external surface (22) of the inner sleeve (3).

6. A rotor coupling according to Claim 5 characterised in that the outer sleeve (4) is longitudinally slotted.

7. A rotor coupling according to Claim 5 or Claim 6 characterised in that the inner and outer sleeves (3, 4) are connected to the cap by screw means (27, 77) which, when tightened, urge the sleeves (3, 4) together to clamp the inner sleeve onto the rotor.

8. A rotor coupling according to Claim 7 characterised in that the screw means (27, 77) comprises screws or bolts which extend parallel to the common axis of the sleeves (3, 4).

9. A rotor coupling according to Claim 8 characterised in that the inner and outer sleeves (3, 4) have annular external flanges (19, 20) formed with registering plain-bore holes (24, 25) and disposed opposite an annular face of the cap in which are internally screw-threaded holes (26) with which the plain-bore holes of the flanges register, the screws or bolts (27, 77) being located in the plain-bore holes (24, 25) and tightened into the screw-threaded holes (26) of the cap (2) to clamp the inner sleeve (3) onto the rotor.

10. A rotor coupling according to any preceding claim characterised in that a keeper device (71) is provided which clamps to the cap (2) and is adapted to engage with an annular groove in the rotor to retain the rotor to the cap.

11. A rotor coupling according to Claim 8 and Claim 10 characterised in that the inner and outer sleeves (3, 4) have annular external flanges (19, 20) formed with registering holes (24, 25) and disposed opposite an annular face of the cap (2) through which open corresponding

holes (63) formed through the cap parallel to the common axis of the sleeves (3, 4), the keeper device (71) having internally screw-threaded holes (73) which register with the holes (24, 25;63) in the flanges (19, 20) and cap (2), and bolts extend through the holes of the cap and flanges and are tightened into the internally screw-threaded holes (73) of the keeper device to retain the inner sleeve (3) to be clamped onto the rotor.

12. A rotor coupling according to any of Claim 1 to 9 characterised in that retention means (5) is provided adapted to hold the rotor to the cap (2) when the gripping means (3, 4) is not applied for retaining the rotor in the cap.

13. A rotor coupling according to Claim 12 characterised in that the retention means (5) comprises a pin or pins, or the like, insertable laterally of the rotor into a location or locations in the rotor though a locating aperture or apertures (33) in the cap (2).

14. A rotor coupling according to Claim 13 characterised in that a collar (6) is mounted on the cap (2) which is movable relative to the cap between an operative position, in which it overlaps an outer end of the or each pin (5) to prevent withdrawal of the pin from the location, or respective location, in the rotor, and an inoperative position in which the collar (6) is moved clear of the pin or pins (5) so as to allow withdrawal of the pin or pins from the location or locations for release of the rotor from the cap.

15. A rotor coupling according to any preceding claim characterised in that the cap (2) is made in one piece.

16. A rotor coupling according to any of Claim 1 to 14 characterised in that the cap (21) is of a composite form comprising a body part (60) which contains the gripping (3, 4) means and a head part (61) which is attached to the body part and is adapted to be connected to the drive shaft of a rotary degassing machine.

17. A rotor coupling according to Claim 16 characterised in that the head part (61) is replaceable by one or more other head parts to suit different drive shafts.

18. An assembly characterised in that it comprises a graphite rotor (37) and a rotor coupling (1) as claimed in any preceding claim to which the rotor (37) is removably connected.

19. An assembly according to Claim 18 characterised in that the rotor (37) has a non-circular cross-section to assist in the stirring action in a melt.

20. An assembly according to Claim 18 or Claim 19 characterised in that an opposite end of the rotor (37) from that at which it is connected to the rotor coupling (1) is enlarged or has an enlarged end part (47) connected to it to enhance the stirring action of the rotor in use.

21. An assembly according to Claim 20 characterised in that the enlarged end or end part (47) is castellated, ribbed or otherwise formed to induce turbulence in the stirring of the melt.

22. An assembly according to Claim 21 characterised in that the enlarged end or end part (47) is reinforced to increase resistance to wear from the stirring action in use.

23. An assembly according to any of Claims 18 to 22 in which the cap (2) of the rotor coupling (1) and the rotor (37) have communicating gas passages (39) for a degassing gas to be introduced into a melt.

24. An assembly according to Claim 23 as dependant from Claim 21 characterised in that the enlarged end or end part (47) is of square shape in plan having oblong downward projections (81) on its underside along side edges thereof, there being gaps (82) between the projections (81) at the side edges for degassing gas passed through the communicating gas passages (39) of the cap (2) and rotor (37) to pass laterally from the enlarged end or end part into the melt, the projections (81) being arranged so as to turn through the paths of the gas as the gas passes out of the gaps (82) to assist in breaking up bubbles in the gas flow for dispersion in the melt.

25. A rotary degassing machine having a powered drive shaft (12) and an assembly as claimed in any of claims 17 to 23 detachably connected to the drive shaft (12) by the rotor coupling (1).

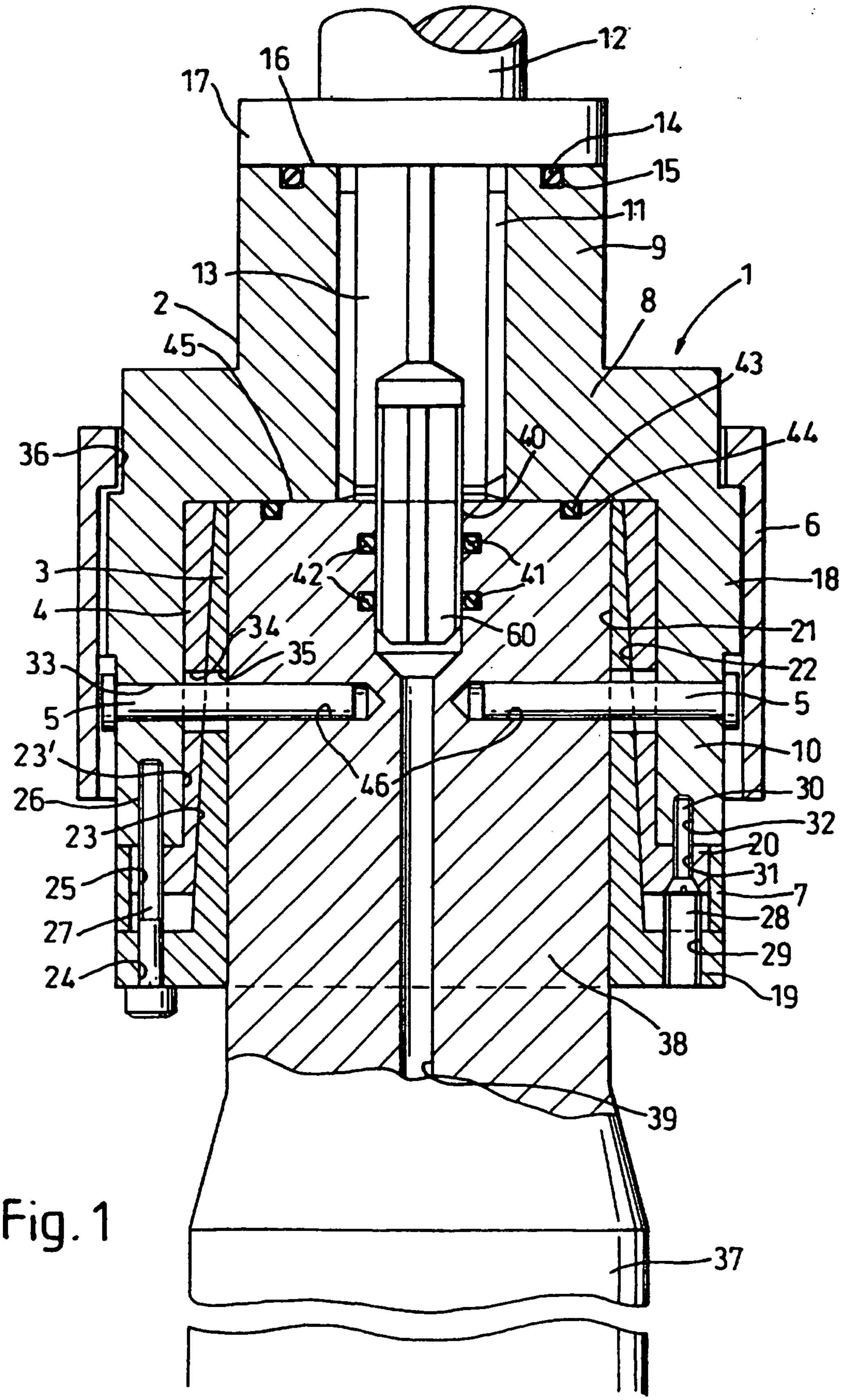
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Fig. 1

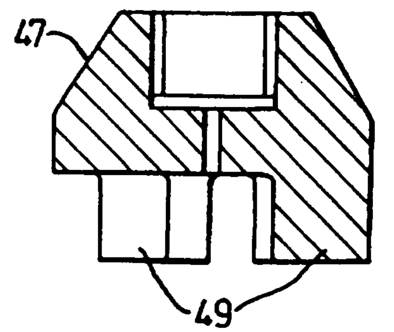

Fig. 2

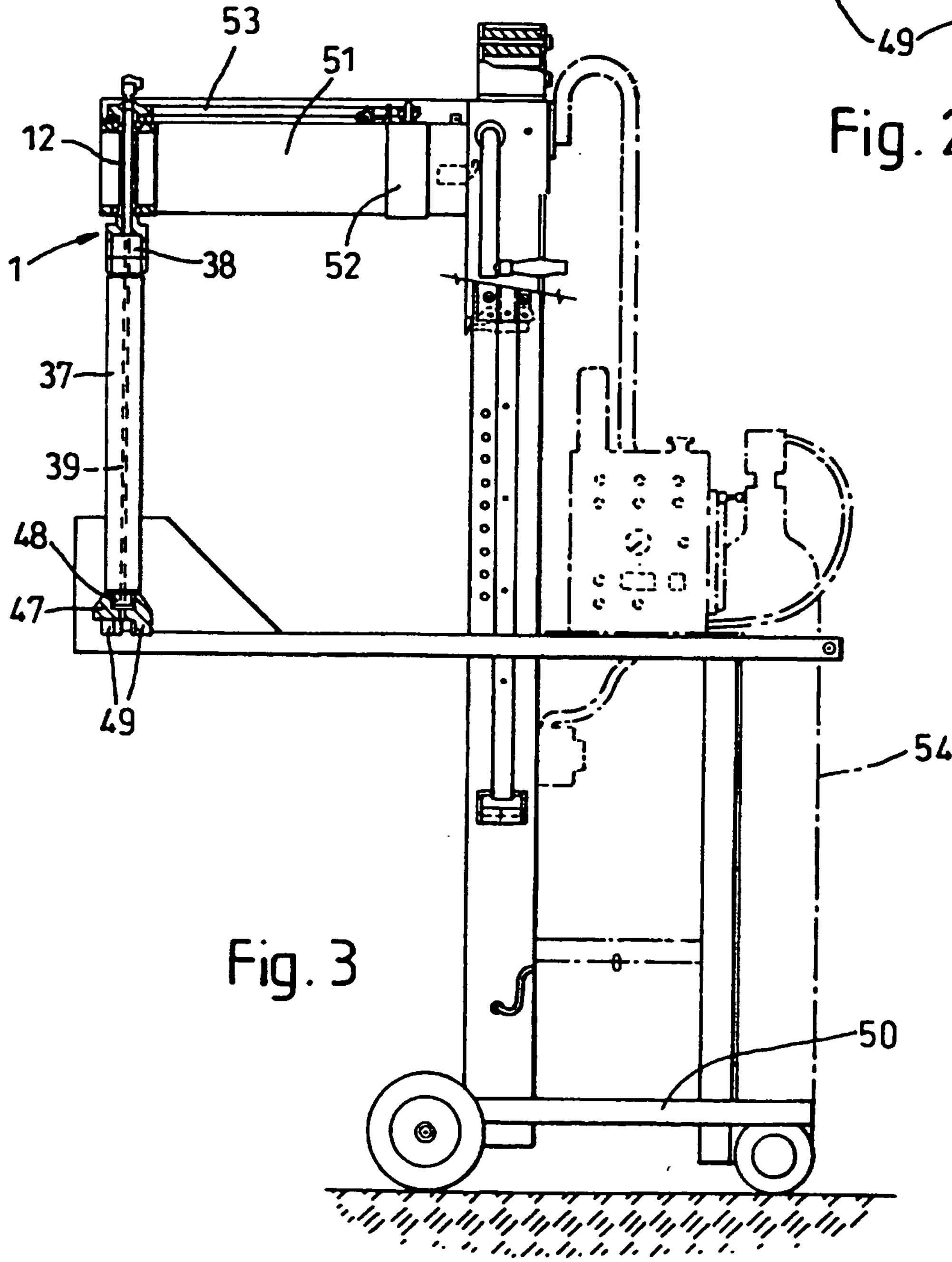

Fig. 3

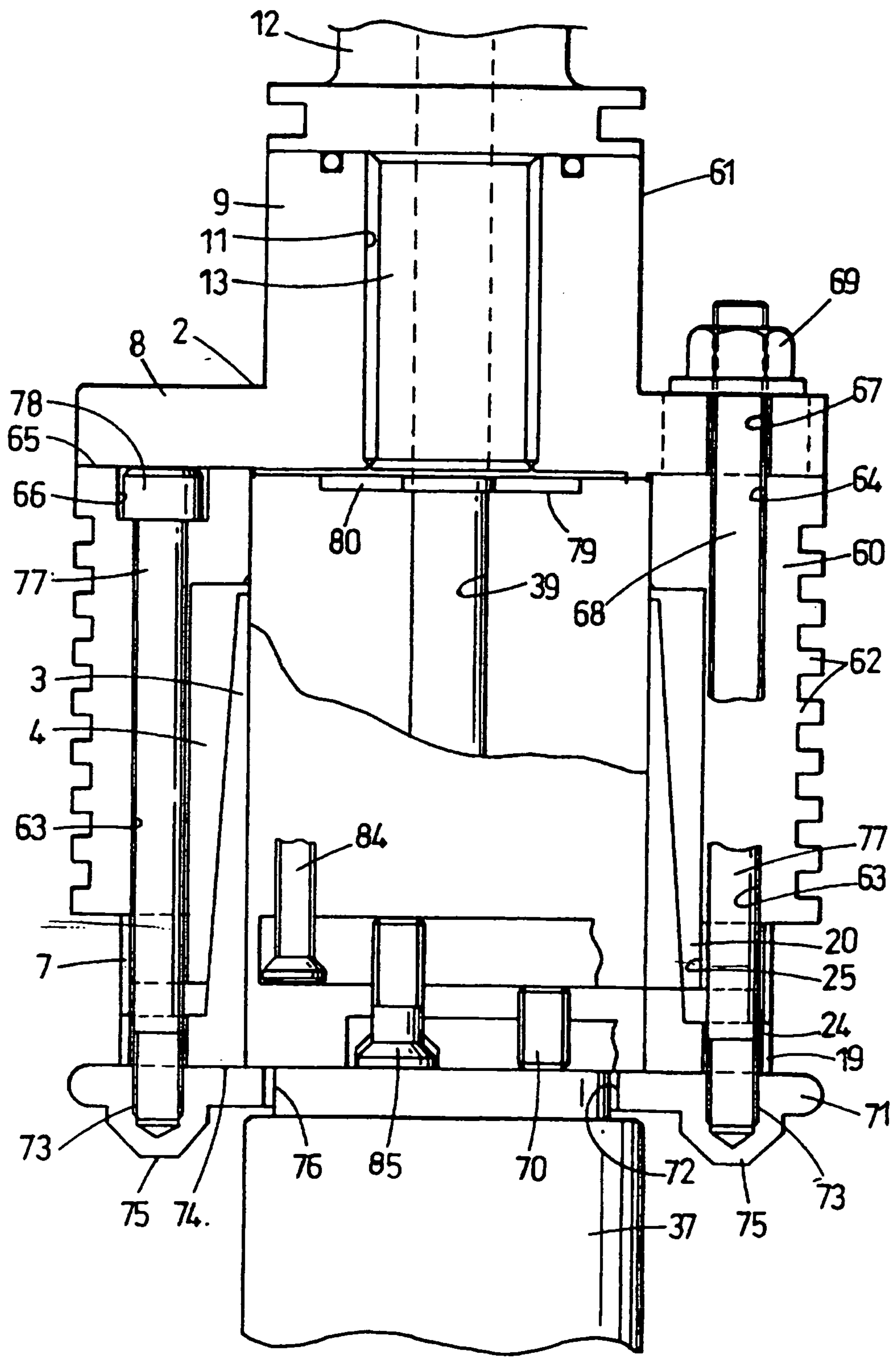
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Fig.4

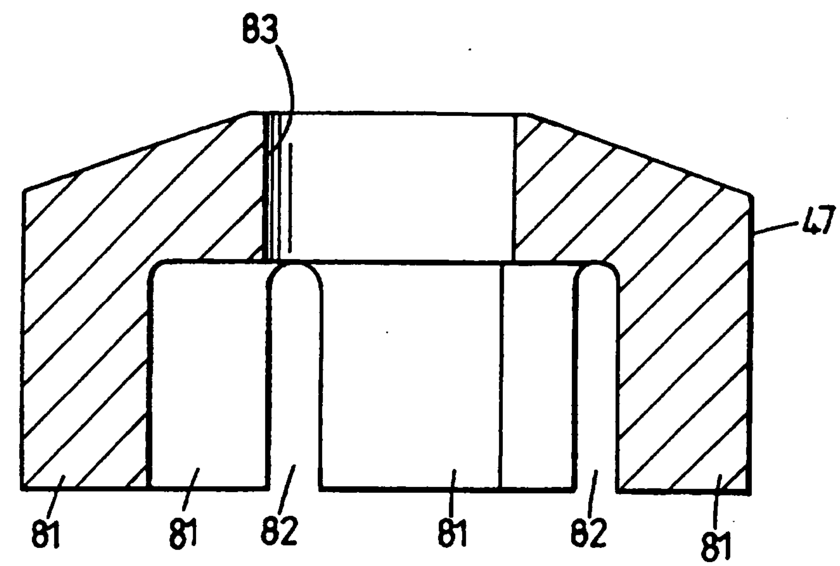

Fig. 5

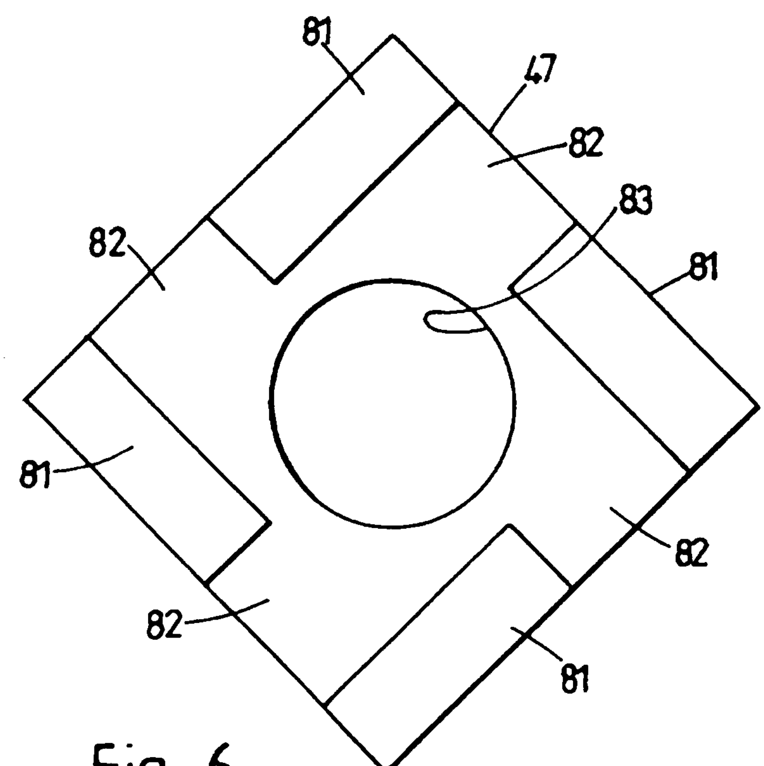

Fig. 6

INTERNATIONAL SEARCH REPORT

Interr. .al Application No
PCT/GB 97/02269

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C22B9/05 C22B21/06 F27D23/04 F16D1/05

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C22B F27D F16D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	DE 195 39 621 A (BAYER AG) 5 June 1997 see column 2, line 53 - line 59; figure 1 see column 19 - column 25	1-4,15, 18,20, 21,23,25
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A	DE 71 35 511 U (HOESCH AG) 30 December 1971 see page 5; claims 3-5; figures 3,4	1,2,15, 18-23
A	EP 0 362 437 A (UNION CARBIDE) 11 April 1990 see page 2, line 19 - line 39; claim 1; figure 1	1,18

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 December 1997	15/12/1997

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bombeke, M

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/02269

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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DE 3625996 A	04-02-88	NONE	